Balsa Wood Structure Data Base

(misc. information for coaches and teams)

GENERAL

– Keep it simple, keep it straight, keep it level, keep it smooth, keep it well-glued.

– An 18 gram structure may hold up to 25,000 times its weight (approx. 1,000 lb. and sometimes more).

– For more information on balsa safety, visit Ken Coviak's "OM Safety Issues" web site.

SAFETY

– When working with glue, accelerator, or acetone, remember that they are toxic and hazardous materials. Follow all guidelines and precautions accompanying these materials. It is easy to become complacent, as the hazard is not immediately obvious. Safe use of these materials requires that they always be handled with care and respect.

– Work in a well ventilated area. Keep sources of flame and sparks well away from the work area. This includes not only the obvious things like ranges, furnaces, fireplaces, cigarettes, lighters, matches, and candles, but also the less obvious, such as pilot lights on gas appliances, and the sparking that can occur in the electric motors found in power tools and various appliances.

– Keep food and drink away from the work area.

– Always wash hands after working with glue materials. Keep glue, accelerator, and acetone away from the eyes. Safety glasses are recommended. Avoid rubbing the eyes, and keep the hands away from the face, while working with these materials.

– If power tools are used, eye protection, instruction in the safe use of the tools and proper supervision should all be considered prerequisites.

– It is quite easy to cut fingers when using very sharp cutting instruments such as razor blades and X-acto knives. Holding material in one hand while trying to cut it is VERY dangerous – and should be avoided.

– Keep all materials and tools out of reach of younger children.

BALSA WOOD

-- Straight grained wood is generally preferred over wood with crooked grain.

-- The term "grain runout" is used to describe a piece of wood where the grain does not run the entire length of the piece.

-- The average density (and resulting weight) of balsa wood can vary by as much as a factor of four. Density must be considered carefully since the completed structure cannot exceed the weight limitation of the problem.

-- In balsa, the key structural properties (tensile, compressive and shear strengths) vary greatly over the range of available densities. Consequently, two sticks of balsa that look very similar can differ by more than a factor of 10 in the load they can support.

CONSTRUCTION

-- A load placed in the center of a long board supported at each end will be distributed evenly between the two supports. If that load is moved closer to one of the ends of the board, more of the load will be supported by the closer support. How a load is to be distributed influences the design and testing of all structures.

-- There are certain construction/reinforcement situations in which laminated pieces may provide a better alternative than single pieces, the longitudinal stringers and nodes that plants grow in nature are an example, but check the rules each year to insure laminations are, in fact, allowed.

-- Buckling causes most structure failures. Simply put, trusses and vertical members should be well braced and the bracing carefully thought out to prevent the structure from bending or twisting. Generally speaking, crossed braces prevent twisting while horizontal braces prevent bending. -- *Jim Stevens*

--In any structure, the downward forces may not always act in the same, uniform way throughout the structure due to minor (or major) differences in construction techniques and/or the quality of construction. Quality workmanship can prevent early structural failure.

-- The diameter of the pieces of wood used can vary if the rules permit. Smaller diameter wood, however, does not always equal less weight than wood of a larger diameter. It depends on the density of the wood involved.

-- Unintentional curves or bends in any structure can cause that structure to break sooner than it otherwise might. Balsa wood sticks will bend at different places and break, just like sticks of uncooked spaghetti, depending on the amount of weight placed on them. The length where the wood no longer bends, but crushes instead, is generally known as the "critical length," while the amount of weight required to cause a stucture to fail is generally known as the

"buckling load."

– Each time you divide a length of wood in half, it takes four times as much force to bend it. As an example; a short piece of uncooked spagetti is much harder to bend than a long one. If you divide a length of wood into three equal parts it would require nine times the force to bend it; four times requires sixteen times the pressure, etc. The principle behind this comes from the Law of Squares known as Euler's (pronounced "oiler's") formula for the buckling load of a strut (for those wanting to look deeper into the math).

– In any structure, forces may not always act in the same, uniform direction. For example, if a structure is not level, the forces acting upon it are unevenly distributed.

– If the top and bottom feet of a structure are not flat with the top and bottom of the tester, uneven weight distribution can result.

– Wood pieces that have been cut or sawed have crushed cell structure at the cut end of the wood. Sanding wood, in general, does not crush the cell structure.

GLUING

– Careful use of fine sandpaper prior to gluing will remove any fuzz or coarse material. It is very easy, however, to unintentionally round off flat edges while sanding so care should be exercised.

– Many glue containers instruct the user to spread the glue around to properly "wet" the surfaces to be joined prior to connecting them. Some also recommend placing glue around the joint of joined pieces for added holding strength, however, teams should remember that excessive gluing may result in exceeding the weight limitations of the problem.

– Glued pieces should be placed under slight pressure for the time indicated by the glue manufacturer to insure good contact.

– White glue, such as Elmer's, never gets hard. Yellow glue, such as wood glue, hardens. Cyanoacrylate (CA) glues (often referred to as super glues) become both hard and brittle.

– The surfaces to be glued can be prepared first by sanding and/or by following directions provided by the glue manufacturer to avoid gaps which many glues cannot adequately fill and still provide a good bond.

– Thicker grades of glue take longer to set. Thicker glue can be useful if additional time is needed for placement of various parts.

– It can require several hours before some glues reach full strength.

– Rough surfaces do not glue well. This is one of the reasons why the end surface of a piece of balsa may not glue well to another surface.

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near glue bottles can lead to hardening of the glue in the bottle top (or even the glue in the bottle itself). Accelerator should be used lightly (as only a little is needed) and carefully. Care should be taken to avoid getting glue or accelerator on the skin.

JIGS

-- A jig is a "holding" device that allows you to place and hold structure pieces while you align and/or glue everything together.

-- Jigs can be made out of wood, cardboard, or any material a team can think of that will hold the pieces accurately.

-- Any jig, to be useful, must be accurately designed and built.

WEIGHT PLACEMENT

-- Use care in placing weights so the weight stack does not sway or wiggle. Rotational harmonics (swaying) can be passed easily to your structure and break it.

-- Be careful when placing weights to avoid pinching your fingers between weights. Plan and practice your weight placement.

TIPS FOR BUYING BALSA

-- There are several grades of balsa wood, each having different characteristics. There is a four page discussion of the various grades and qualities of balsa wood available from SIG Manufacturing (see below). Be very careful when buying wood to make sure you are getting Balsa. There are other woods that have a similar look. If you are buying from a retail store, ask store personnel to explain the difference and have them show team members ways of determining that what they are buying is, indeed, balsa and not something else. Be very cautious about the wood you buy!

-- Balsa does vary from about 2lb/cubed foot to about 6lb/cubed foot. Any number of books about building model airplanes go into more detail about this. Try the 629 (Dewey Decimal System) area of your public library. It will have more than one how-to book on building balsa wood airplanes and a discussion of density and grain. Also, consult magazines such as American Modeler.

-- Because of inconsistencies in weight and the lack of uniformity in any supplier's stock, the pieces used by the team should be carefully selected...but without outside assistance!

-- Make sure that you are buying balsa and not basswood, which looks nearly identical but is

illegal to use in OM. Basswood is heavier and smoother than balsa, whereas balsa is lighter and its wood pores are more open. Some suppliers may also carry spruce, which is a bit easier to identify since it is heavier and stiffer than basswood and darker in color.

-- Balsa is available at retail stores, but many teams buy by mail order from companies like SIG or Balsa USA. You must purchase in bulk from these suppliers, but the cost per piece will be less than if you buy smaller amounts at the local store. Your order should arrive within five working days or even less if your willing to pay for special shipping. Balsa is normally sold in 36" long sticks.

SOURCES FOR BALSA WOOD

-- SIG Manufacturing, 401 Front Street, Montezuma, IA 50171. Phone: 800-524-7805. You can order general stock or specify "hand selected" grades of wood in light, medium or hard densities.

-- Balsa USA. Phone: 1-800-225-7287. You can order general stock or specify "hand selected" grades of wood in light, medium or hard densities.

-- Hobby Woods, 2931 Larkin, Clovis, CA 93612. Phone: 209-292-WOOD (9663)

-- Swenson Specialties, P.O. Box 663, 2895 Estates Ave., Pinole, CA 94564. Phone: 510-758-0179 Fax:707-746-0554

-- Superior Aircraft Materials, 12020-G Centralia Ave., Hawaiian Gardens, CA 90716. Phone: 310-865-3220 FAX 310-860-0327. You can specify "grades" A through D and they will hand pick wood that weighs within that grade range. Grades are: A = 2.0 - 2.4 || B = 2.5 - 3.0 || C = 3.0 - 4.0 || D = 4.0.

SOURCES FOR BALSA WOOD TOOLS

-- Northwest Short Line, Box 423, Seattle, WA 98111-0423. Phone: (206) 932-1087. They sell something called "The Chopper" and "The True Sander" which may be worth checking into, especially for younger teams with less developed hand-eye coordination.

BOOKS ON STRUCTURES

-- Building and Flying Indoor Model Airplanes, by Ron Williams. Fireside, Simon and Shuster, 1981. ISBN 0-671-41366-X

-- Structures: Fundamental Theory and Behavior, by Richard M. Gutkowski. Most of the book is very mathematical and beyond the scope of OMers, but the end of chapter 2 has a good

discussion on stability and bracing, with diagrams.

-- Structures: Or Why Things Don't Fall Down, by J.E. Gordon. Penquin Books, 1978. ISBN 0-306-80151-5

-- The Art of Construction, by Mario Salvadori. Chicago Review Press, 1990. ISBN 1-55652-080-8

MISCELLANEOUS

-- A structure may add weight by absorbing moisture from the air. A team should be prepared to deal with this fact. Drying the structure using various techniques can reduce any weight gained from moisture in the air.

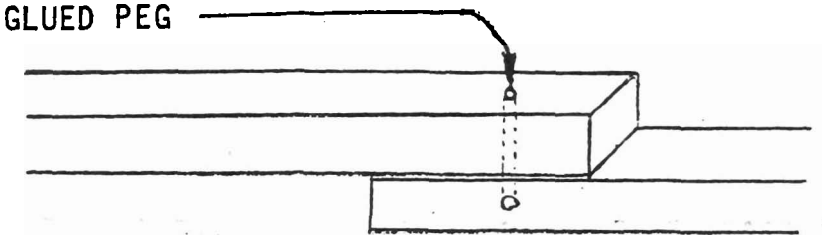
-- The purpose of a truss on bridges is to spread the weight out over the bridge and toward the points where the bridge is anchored on either end. Looking at pictures of bridges, the observer quickly sees that trusses are sometimes built above the floor of a bridge or sometimes below it (called an "underslung" truss). Truss design varies depending on purpose.

-- The ideal way to absorb any impact is to stop the moving object at the point of impact. The amount of flex in the wood being impacted depends on the hardness (density) of the wood used.

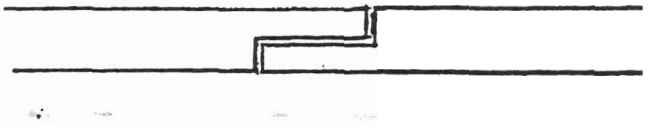
-- Teams should learn all they can about compression and tension in structures. This basic engineering knowledge affects all aspects of any structure.

ANGLE / SCARF JOINT

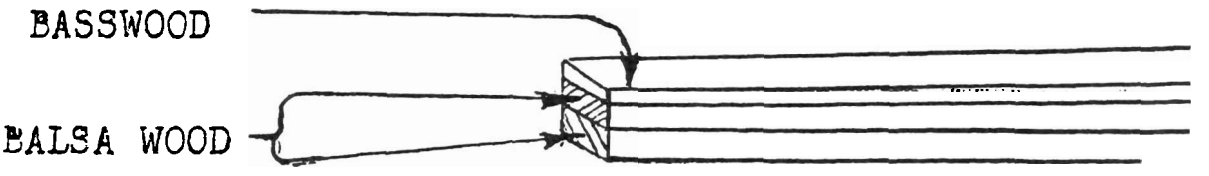
BUTT JOINT



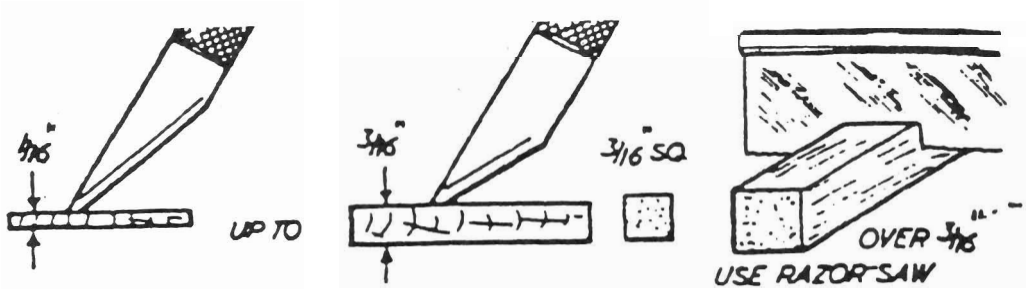
LAP JOINT



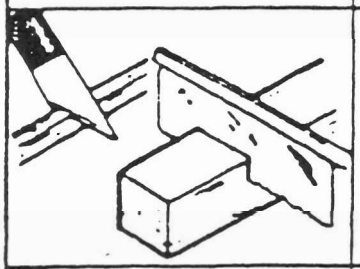
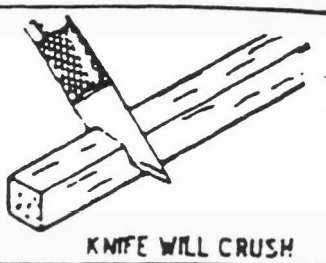
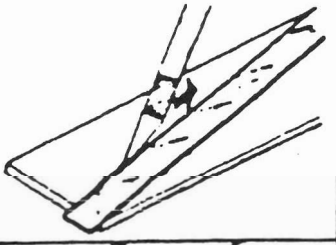
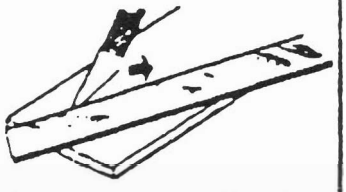
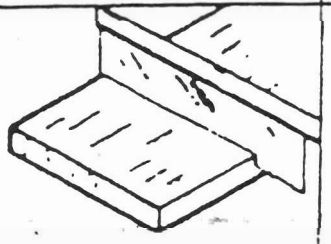
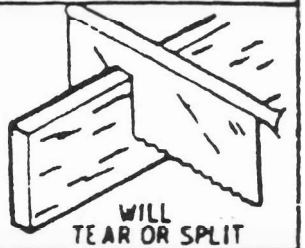
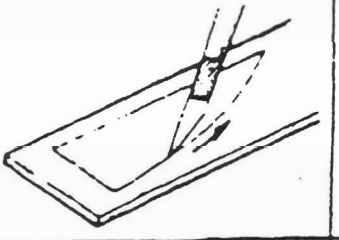
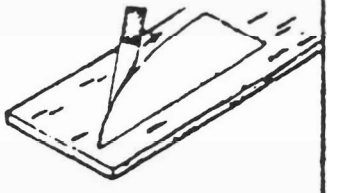
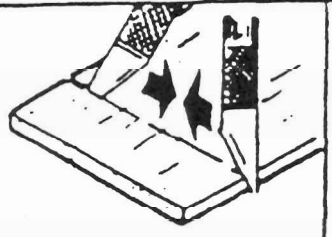
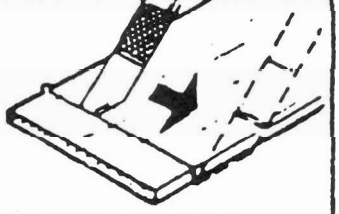
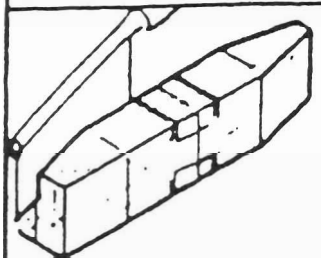
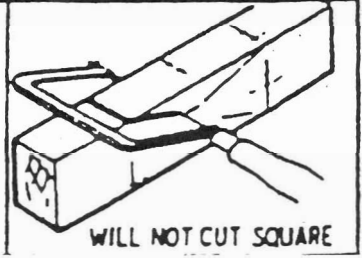
HALF-LAP JOINT



LAMINATION



GENERAL CUTTING GUIDELINES

RIGHT!	TYPE OF CUTTING	WRONG!
	**CUTTING STICKS** USE SHARP KNIFE OR RAZOR BLADE TO CHOP OFF SMALL SIZES - USE RAZOR SAW FOR LARGER SIZES.	 KNIFE WILL CRUSH
	**STRAIGHT CUTS WITH THE GRAIN** USE METAL RULER AS A GUIDE — CUT IN DIRECTION THAT GRAIN PULLS BLADE AGAINST STRAIGHTEDGE	 BLADE WILL RUN OFF LINE
	**STRAIGHT CUTS IN THICK SHEETS** USE A RAZOR SAW — ALWAYS MAKE EDGE TO EDGE CUTS ACROSS THE FLAT SHEET	 WILL TEAR OR SPLIT
	**CUTTING FREEHAND CURVES** CUT IN DIRECTION WHERE GRAIN WILL PULL BLADE AWAY FROM SHAPE — CLEAN UP LATER AS NECESSARY WITH KNIFE AND SANDPAPER BLOCK	 BLADE RUNS INSIDE OUTLINE
	**CROSS GRAIN KNIFE CUTS** ALWAYS CUT FROM EDGE TOWARDS CENTER — NEVER OUTWARDS TO AN EDGE	 EDGE WILL TEAR
	**FOR CUTTING BLOCKS** USE A STIFF BACK SAW AS FAR AS POSSIBLE — CUT IN FROM BOTH SIDES	 WILL NOT CUT SQUARE

Adhesives to Master

Acetate - The traditional "model airplane glue" is a solvent type that evaporates its solvent components to gain its strength. It is still considered the best for lightweight structures because it is quite strong yet does not add excessive mass. The disadvantages are its lacquer odor and the fact that is attacks plastics and foam. Popular types are DUCO, Ambroid, and Testor's "Green Tube" cement.

Cyanacrylates - These are known as "Super Glue" or *Hot Stuff* glues. The cyano-glues were originally designed for closing battlefield wounds before evacuation and was used extensively during the Vietnam conflict. The thin viscosity can bond just about anything together, including fingers. Wood was tremendous capillary action and this thin fluids quickly wick away from the surface. Therefore, only use medium viscosity cyano which tends to remain localized and takes longer to dry. Accelerator can be used to activate cyano to an immediate bond. Try not to dispense with a spray bottle. Instead, locate a "needle tipped" squeeze bottle for delivery. Advantages with cyano glues are fast construction and on site repairs. The disadvantage is fumes (some are fume free) and ability to bond everything, including skin. Acetone, like finger nail polish remover, can de-bond. The oils in your skin will do the same over time. Popular brands are ZAP and Bob Smith Industries.

White Glue (Aliphatic) - A popular adhesive with schools, white glue has two good advantages. The first is "non-toxic" and the second is higher shear resistance (tacky formula) This family of adhesive is the most popular throughout the world. It has some disadvantages though, It by far is the heaviest of all the choices. Up to 50% more mass can be added by being heavy handed with the glue. It does not sand very well, instead, it tends to stretch (shear resistance). It will cause warps in thin structures if applied to heavily and is not waterproof. Popular brands are Tacky Formula, Elmer's, Ailene's.

Construction Concepts

- Lap Joints - surfaces joined one on top of the other.
- Butt Joints - surfaces joined, flush, on the same plane.

- Bad Joints - Those using air, light or mostly glue to hold two surfaces together.
- Gussets - Triangle brace to strengthen a joint. Note the grain runs along the hypotenuse.

1. USE A FAST DRYING GLUE

2. USE WAXED PAPER OR CELOPHANE TAPE TO COVER GLUEING AREA

3. USE FULL QUARTER OR THREE SIXTEENTH WOOD AT FIRST

4. USE EMERY BOARDS OR SANDPAPER BOARDS FOR FILING

5. LAMINATING WOOD PIECES IS A GOOD IDEA

6. PAY CLOSE ATTENTION TO JOINT CUTTING AND STRUCTURE

7. BUILD ONE STRUCTURE PER WEEK UNTIL YOUR DESIGN IS SOUND

8. CHECK WITH MODEL BUILDERS FOR BEST MATERIALS SUPPLY

9. MAKE YOUR OWN GAUGES, JIGS, AND SUPPORTS

10. CONTACT YOUR WOOD SHOP, METAL SHOP, SKILL CENTER, ENGINEERS, TRUSS BUILDERS, LUMBER COMPANIES, ETC.

11. HAVE ALL TEAM MEMBERS TRY BUILDING A STRUCTURE SOME TIME; YOU MAY FIND A GEM.

12. DON'T OVERLOOK PARENTS, RETIRED TEACHERS, MODEL BUILDERS, ETC, AS COACHES.